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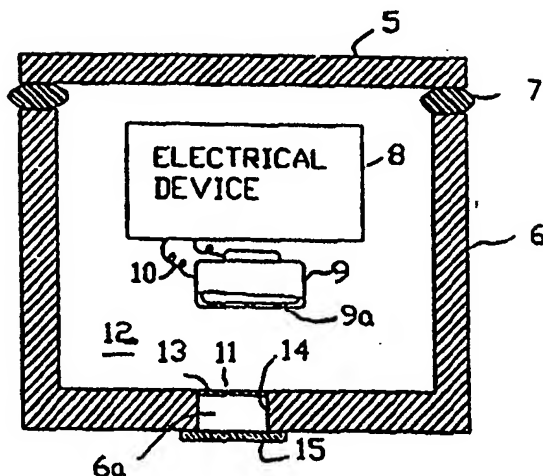
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(54) Title: CONTAINER FOR ELECTRICAL DEVICE UTILIZING A METAL AIR CELL

## (57) Abstract

A water resistant case (6) for an electrical device such as an electric wristwatch movement powered by a standard high current zinc/air cell. A small aperture (11) in the case wall slows ingress and egress of water vapor to the case so as to increase cell life. The aperture also limits the rate of oxygen flow to the cell cathode rather than the air entry ports in the cell itself. A hydrophobic gas transmissive membrane (45) admits air and water vapor to the aperture without admitting liquid water.



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## CONTAINER FOR ELECTRICAL DEVICE UTILIZING A METAL AIR CELL

This invention relates to a container for an electrical device powered by a metal air cell and designed for low average current operation, but which intermittently requires high current. An example would be a wristwatch case which contains an electronic watch movement powered by a zinc air cell and requiring a continuous low current to operate the watch for timekeeping operation, but which includes means to illuminate the timepiece when a push button is pushed, or to operate a radio receiver as in a paging device. These latter devices require a relatively high current during the brief time when they are operating and hence a high current cell is needed to support them.

Metal air cells are well known in the art, these generally comprising a consumable metal anode, a catalytic nonconsumable, oxygen-consuming cathode, and a suitable electrolyte. Metal air cells have been manufactured in the form of miniature button cells for hearing aids and watches and the like. A typical zinc/air button cell generally includes the following components:

1. A cathode can which includes at least one aperture for entrance of air and which contains a nonconsumable air cathode structure usually comprising a gas permeable hydrophobic polymer film onto which is pressed a metal current collection grid and a waterproof, porous catalyst material such as metal catalyzed activated carbon admixed with a hydrophobic binder. Although actually an independent component of the cell, one or more electrolyte-absorbing separator layers are placed on the catalyst layer of the cathode structure to separate it from the anode.

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2. An anode can which is joined to the cathode can typically by crimping and which includes a zinc anode mass typically in the form of amalgamated zinc powder (e.g., containing 3 - 8 w% Hg) or of a porous zinc compact, saturated with an alkaline electrolyte such as a 30 - 40% aqueous solution of KOH.

3. A polyethylene, polypropylene, nylon, etc. insulator between the cathode and anode can which insulator also functions in many cases as an electrolyte seal.

Control of the admission of air to the air-consuming electrode is provided by small holes in the button cell container as illustrated in U.S. Patent No.; 3,897,265 issued July 29, 1975 to Jaggard. Such cells are suitable for relatively high current drains such as 10 milliamperes which are used in hearing aids. Subsequently, zinc/air cells have been developed for long life, low current drain, as required in electric wristwatches by adding a special membrane to control the admission of oxygen to the air-consuming catalyst. One such type is known in U.S. Patent No. 4,105,830 issued August 8, 1978 to Kordesch which is permeable to oxygen. Another approach is shown in U.S. Patent 4,118,544 issued October 3, 1978 to Przybyla et al. using very tiny pores or passages through a barrier to the cathode.

In all of the foregoing constructions, the means for controlling the admission of oxygen to the cathode is tailored for a specific application or range of current drain expected to be encountered by the cell. The foregoing constructions do not lend themselves to alternate operation of the cell in either a low average current mode or a high current mode.

Prior art teaches that the ingress and egress of gases such as air or water vapor, into and out of a zinc/air battery, can be slowed by restricting the opening(s) in the walls of the cell required to allow entry of air to the

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cell. Control of relative humidity is especially important for extending cell life. A zinc/air cell will dry out in a low humidity atmosphere and Rood in a high humidity condition. Both conditions prevent the full rated capacity of the cell from being realized over a longer period of time and are especially significant at low average drain rates, i.e. in cases where the rated capacity would not be depleted in six weeks or less. The initial concentration of the battery electrolyte establishes the internal relative humidity (RH) of the cell at approximately 58%. Exposure of the activated cell to ambient RH levels, more or less than this value, causes ingress or egress of water vapor, respectively. Ingress or egress of water vapor can be restricted by reducing the size of the air admission holes. But the opening that restricts transfer of water vapor also limits transfer of oxygen to the cell. The opening in a high current cell must be sized to accommodate the oxygen ingress necessary to sustain the maximum rate of discharge.

Metal air cells having a high current drain capacity, such as those used in hearing aids, are unsuitable for use in wristwatches without modification. Metal air cells have been modified for use with electrical devices requiring a normal low average current drain with intermittent requirements for high current drain. Examples of such modification are seen in U.S. Patent 4,262,062 - Zatsky issued April 14, 1981 assigned to Applicant's assignee, and in U.S. Patent 5,451,473 Oltman et al. issued September 19, 1995. In the latter patent, a metal air cell includes a restrictive membrane controlling the flow of air from air entry ports in the bottom of the cell into an internal air reservoir. The air reservoir provides sufficient oxygen to the cathode assembly during short periods of high current drain upon the cell.

Another means for matching the cell to the electrical device receiving energy from the cell is shown in U.S. Patent 5,191,274 issued March 2, 1993 to Lloyd et al. In this patent, the number of air admission or supply holes to the cell are controlled by a seal which determines the number of holes or ports which are activated to admit oxygen to the interior of the cell. In all of the foregoing prior art, the design of the metal air cell itself determines the flow rate of air to the cell.

It is also known in the prior art to place an electrical device and a metal air cell which is designed to match the current requirements of the electrical device in a container. Since the cell requires a supply of air to operate, the container cannot be hermetically sealed. The prior art has allowed a generous supply of air to the container to satisfy the current requirements of the electrical device under all conditions. This admission of air with accompanying water vapor permits the relative humidity within the container to fluctuate widely as determined by many factors such as variations in the ambient relative humidity outside the container, temperature variations of the container and depletion of oxygen by the cell. However, water in liquid form may also enter the container through the air entry passages if the device is subjected to excessive moisture or intended for operation underneath water. It is known to utilize hydrophobic gas permeable membranes in the container walls, which admit air without admitting water in the liquid state. An example of such a housing for an instrument is disclosed in U.S. Patent 4,292,681 issued September 29, 1981 to Kloss et al. The Kloss patent discloses a container for an electrical device having a lid and a seal, in which either the seal itself, or an aperture in the lid, or the housing itself may be composed of a hydrophobic, gas permeable, microporous substance.

Referring to Fig. 1 of the drawing, a prior art container for an electrical device is depicted in U.S. Patent 4,292,681 to Kloss. The housing consists of portions 1 and 2 in which the housing portions are connected in water-tight manner to each other by means of a non-gas transmissive sealing ring 3. The portion 2 which takes the form of the housing lid is provided with a gas passage 4, which is closed by a microporous, hydrophobic component. The air oxygen elements (electrical device and metal air cell) which are housed within the enclosure are supplied with air through this component which may, for example, be made of unsintered polytetrafluoroethylene. It is also possible to provide several such air transmissive apertures, closed off by microporous sealing bodies. By way of example, the zinc/air cell contained within the housing utilizes about five microliters of air per hour. In the event of immersion in water, the watch continues to run utilizing the air contained within the housing.

The zinc/air cell described in the aforementioned prior art must be especially adapted for a wristwatch, if it is to have any useful practical life, by means of air flow restrictive membranes inside the cell or by similar devices such as those described in the aforementioned U.S. Patents 4,292,681; 5,191,274 or 5,451,473. In the Kloss patent, the use of such a hydrophobic, gas permeable material (usually in the form of a membrane) is for the purpose of restricting the ingress of water in the liquid state without attempting to substantially restrict the rate of ingress of air or other gases, including water vapor.

Accordingly, one object of the present invention is to provide an improved container for an electrical device powered by a metal air cell which will extend the life of the cell.

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Another object of the present invention is to provide an improved container for extending the life of a high current capacity metal air cell supplying energy to an electrical device having low average current requirements.

Another object of the invention is to provide an improved container for controlling the changes in relative humidity experienced by a metal air cell inside the container.

Another object of the invention is to provide an improved process for utilizing a standard zinc/air high capacity cell of the hearing aid type to power a wristwatch movement contained in a water-resistant case.

### SUMMARY OF THE INVENTION

Briefly stated, the invention comprises a container for controlling the rate of ingress and egress of air and water vapor to a high current metal air cell supplying energy to an electrical device having low average current requirements and intermittent high current requirements, the metal air cell and the electrical device both being disposed in the container with the metal air cell having air entry ports sized to admit a flow of oxygen substantially in excess of that necessary for the cell to supply the low average current requirements of the electrical device. The container comprises a sealed housing defining an air reservoir containing the metal air cell, the sealed housing having a wall defining a restricted flow passage communicating between the air reservoir and the atmosphere outside the housing and sized to admit flow rate of oxygen only sufficient to satisfy the low average current requirements of the electrical device. In its preferred form, the housing further includes a hydrophobic gas permeable membrane disposed between the restricted



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flow passage and the atmosphere outside the housing and adapted to block entry of liquid into the housing while admitting flow of oxygen to the restricted flow passage. In the preferred embodiment, the restricted flow passage is a tiny hole in the container wall having a diameter of approximately .08 mm (.0032 inches) which is supplied from an aperture covered with a GORE-TEX® membrane. Alternatively, any other material having hydrophobic gas transmissive or gas permeable properties can be used.

### DRAWINGS

Other objects and advantages will better be understood by reference to the following specification, together with the accompanying drawings, in which

Fig. 1 is a simplified diagrammatic elevation view in cross section of a prior art container for an electrical device,

Fig. 2 is a simplified diagrammatic elevation view in cross section of a housing for an electrical device and energy cell in accordance with the present invention,

Fig. 3 is a similar view illustrating a modified form of the invention,

Fig. 4 is a similar view illustrating a further modified form of the invention,

Fig. 5 is a similar view illustrating a further modified form of the invention, and

Fig. 6 is a similar view illustrating a further modified form of the invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

The container according to the present invention, in its simplest form, is illustrated in simplified diagrammatic form in Fig 2. A sealed housing is provided by means of portions 5 and 6 connected in watertight manner to each other by means of a non-gas transmissive sealing ring 7. Disposed inside the housing is an electrical device 8, which requires supply of electric energy from an energy cell 9 connected electrically thereto by leads 10. Since the figures of the drawing are shown in simplified diagrammatic form, no mechanical structure or supports are shown for electrical device 8 or 9, it being understood that these are required. Electrical device 8 is intended to represent a device such as an electric watch movement or electric instrument which requires a continuous low current flow for timekeeping in the microampere range (2 to 250 microamperes) and also periodically or intermittently requiring high current flow in the milliamperes range (2 to 12 milliamperes). An example is an electric pager wristwatch which consumes a steady current of around five microamperes to operate the timekeeping functions, but which intermittently requires a relatively high current on the order of 10 milliamperes to operate the pager. Since the pager is operated only occasionally, the average current drain is low.

The energy cell 9 is a standard high capacity or high current flow zinc/air cell such as used in hearing aids, for example cell number 13 or number 675 which is commercially available but which has not been modified to restrict the air supply to the cathode structure by one of the previously discussed schemes. As such, the high current zinc/air cell 9 is designed to have a useful life only on the order of three to six weeks after being activated by removing the covers to its air entry ports shown as 9a.

All cells of this type are sensitive to changes in relative humidity and other atmospheric conditions which may alter the chemistries in the cells causing battery degradation and premature energy depletion. In a low humidity environment, moisture evaporates from the electrolyte and will escape from the cell, decreasing the volume of electrolyte and ultimately causing desiccation. In high humidity, the cell will be caused to gain water which has the effect of diluting the electrolyte and eventually flooding the cell. In this case, the dividing line between "low" humidity and "high" humidity is an equilibrium value of relative humidity which the cell tries to maintain by its internal chemistry, of about 58% relative humidity. Above 58% relative humidity, the cell takes on water and below 58% relative humidity, the cell loses water. The gains and losses of water are enabled by diffusion of water vapor into and out of the air entry ports 9a in the wall of the cell.

Air also flows into the cell 9 through air entry ports 9a and the oxygen is consumed by reaction with water to produce hydroxide ions. Examples of number and size of typical air entry ports in typical commercially available high current zinc/air cells hearing aid cells are given in the following table:

Cell	No. of Holes	Hole Size Diameter		Total Flow Area	
		mm	(Inches)	mm <sup>2</sup>	(in <sup>2</sup> )
A	4	.51	(.020)	.82	(.0013)
B	2	.46	(.018)	.33	(.0005)
C	6	.28	(.011)	.37	(.0006)

The flow of oxygen which would be admitted through the air entry ports above is substantially in excess of that necessary for the cell to

supply low average current requirements of the electrical device in the microampere region, but is sufficient to supply momentary high current requirements of the electrical device on the order of a few milliamperes.

In accordance with the present invention, the ingress and egress of water vapor and the ingress of air (oxygen) for sustained low average current requirements of the electrical device are controlled by means of a restricted flow passage 11. Passage 11 communicates between an air reservoir 12 inside the housing and the ambient atmosphere outside the housing. In the embodiment depicted in Fig. 2, the restricted flow passage comprises a tiny hole drilled or formed by laser in a metal plate 13. Plate 13 is sealed or otherwise supported within an aperture 14 in the wall of housing portion 6. A suitable size of the restricted flow passage 11 to support a low average current drain of 2 milliamperes is a small single hole with a diameter of .08 mm (.0032 inches), or a flow area of .005 mm<sup>2</sup> (.000008 in<sup>2</sup>). A useful range of hole diameters for a restricted flow passage 11 is between 0.05 mm and 0.1 mm, depending upon the expected low average current drain. This diameter can be calculated or determined empirically. The flow of air through a hole of this size into air reservoir 12 is sufficient to satisfy the low average current requirements of the electrical device 8 on a sustained basis. However, we have discovered that the hole also substantially impedes and slows down the diffusion of water vapor into and out of air reservoir 12, and substantially lengthens the useful life of the metal air cell. In the event of blockage of the hole or in the event of high current drain requirements on the part of electrical device 8, reservoir 12 supplies the needs of cell 9 for a short time.

Referring to Fig 3 of the drawing, another embodiment is shown, in which the same elements are indicated by the same reference numbers

as in Fig. 2. However, in this case, the plate 13 with its restricted flow passage 11 is located toward the inside of aperture 14 and the outside of aperture 14 is closed off with a hydrophobic gas transmissive element comprising a membrane 15. Membrane 15 is preferably a foil of unsintered polytetrafluoroethylene. One suitable membrane 15 commercially available under the brand name GORE-TEX®, which permits air and water vapor to permeate but inhibits passage of water in a liquid state. The membrane 15 covers aperture 14 and is supported and sealed around its edges on the container wall. A chamber 6a in the wall of housing 6 between hole 11 and membrane 15 collects air and water vapor which passes through the pores of the membrane. Membrane 15 is not designed to appreciably restrict the flow of air to the air reservoir 12, this function being accomplished by the restricted flow passage 11. The size of the aperture is selected so that the flow of air through membrane 15 is sufficient to satisfy the low average current requirements of the electrical device. However, membrane 15 assures flow of sufficient air to chamber 6a without permitting the entry of water in liquid form so that continuous operation of electrical device 8 can continue in inclement weather. In the event of complete immersion of the housing in water, cell 9 is supplied with air from reservoir 12 for a substantial length of time under low current drain requirements. In the event of momentary high current requirements, cell 9 is likewise supplied for short periods of time from air reservoir 12 surrounding the cell. Since water vapor is a gas, it too will pass through membrane 16. Its rate of ingress or egress by diffusion is greatly slowed by the combined action of the membrane and the restrictive flow passage 11.

Referring to Fig. 4 of the drawing, a modified housing portion 16 is shown having a lid 5 and sealing ring 7 as before. Inside the housing is

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a battery compartment wall 17 which defines a battery compartment 18, serving as an air reservoir surrounding cell 9. A removable battery cap 19 provides access to the battery compartment 18. Cap 19 is provided with a sealing gasket or O-ring 20, and may be attached to housing 16 by a bayonet lock or screw threads or any suitable method. Cap 19 defines an aperture 21. Sealed within aperture 21 on the inner side facing the battery compartment is a plate or washer 22 with a restricted flow passage 23 similar to that previously described for restricted flow passage 11. Covering the aperture 21 facing the atmosphere is a gas transmissive hydrophobic material in the form of membrane 24, which may be identical to that described above in Fig 3 by reference number 15. A chamber 19a collects air and water vapor which passes through the membrane 24.

Fig. 4 is representative of constructions often found in an electric watch, where the electrical device is in a compartment separate from the energy cell, the latter being removable through a separate aperture by means of a removable cap such as 19. Electrical leads 25 connect cell 9 to device 8 through seals 26 in wall 17. The Fig. 4 arrangement may be more practical in actual use, since cap 19 may be removed and the flow passage 23 and membrane 24 inspected or tested with ease, in addition to providing for normal replacement of the energy cell 9.

Referring to Fig. 5 of the drawing, a modification is shown which is similar in every regard to Fig. 3, except that the lower portion of the housing identified by reference numeral 27 is constructed of plastic material, such as polycarbonate. An aperture 28 on the outside surface of housing portion 27 connects with a restricted flow passage 29 in the interior surface of housing 27. A suitable diameter of aperture 28 is 1.75 mm (.069 inches). As before, a satisfactory diameter for the restricted flow

passage 29 which is molded in wall at the time of manufacture, is .08 mm (.0032 inches). The drawing is not to scale, but is exaggerated for clarity of presentation. A membrane 15 of hydrophobic gas transmissive material covers aperture 28 and is supported by and sealed to the outer wall of housing 27. An intermediate chamber 30 collects gas passing through the pores of membrane 15 as before.

Another modification is illustrated in Fig. 6 of the drawing, which specifically depicts an electric wristwatch with a plastic case or housing 31. While this embodiment is depicted to show the invention as applied to a watch, it will be appreciated that this can be applied to any electrical device powered by a metal air cell as shown more generally in Figs. 2 - 5. Housing 31 incorporates an interior battery compartment wall 32 defining a battery compartment 33. Compartment 33 contains a pair of series connected metal air cells 34, b. A battery access cap 36 is provided with a sealing gasket or O-ring 20 and attached to housing 31 by a bayonet lock or screw threads. An aperture 37 in the outer surface of the wall of housing 31 narrows to a restricted flow passage 38 on the interior wall inside battery compartment 33. The dimensions of the aperture 37 and restricted flow passage 38 may be as previously described in connection with Fig. 5. Closing off the aperture 37 is a membrane 15, constructed and attached as previously described in connection with Fig 5. Membrane b admits gas into, but excludes liquid from, a chamber 39 which, in turn, supplies battery compartment 33. Series connected zinc/air cells 34, 35 supply a watch movement 40 via leads 41 passing through the battery compartment wall 32. Watch movement b is of conventional construction and includes operating pushbuttons and means to illuminate the watch dial when a pushbutton is operated (not shown). A suitable movement is shown in U.S. Patent 5,265,071 issued

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November 23, 1993 to Thorgersen et al. and assigned to the present assignee, which is incorporated herein by reference. Operation of the pushbutton requires high current for a short period of time of approximately 6 milliamperes. Battery compartment 33 provides an air reservoir which can be preselected in volume to supply the intermittently required high current of the illumination device in movement 40 for a specified time. Restricted flow passage 38 is of sufficient size to supply the low average current requirements of watch movement 8. Such calculations are within the scope of one skilled in the art. A transparent lens 42 is sealed to the housing 31 in order to view the time indicated on the watch movement.

The air reservoir 33 shown in Fig. 6 is designed to be of sufficient size to operate the movement for a selected time at a selected current drain if the air path is blocked. For example, if there are two cells connected in series and if the air in the reservoir is composed of the normal proportion of 21% oxygen, 1 cubic centimeter of volume in the-reservoir (above that occupied by the cells themselves) will provide approximately 1/2 milliampere hour. Therefore, if the container is submerged in water and the movement requires a continuous current supply of 2 ma, the two cells will operate the movement for approximately 15 minutes.

#### EXAMPLE

A test was run under controlled conditions using a 675 hearing aid cell placed in a sealed container with an electrical device arranged to draw 500 milliampere hours over a period of four months. The container was provided with a single aperture of .08 mm diameter (.0032 inches). The relative humidity outside the container was maintained constant for



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three tests over a four month period, one at 10% relative humidity, one at 90% relative humidity and the third at a relative humidity of 58% which is that maintained by the cell electrolyte. In every case, the cell performed properly over the four month period.

In a control test without the container and cell exposed, the same relative humidity conditions were maintained. At 10% relative humidity and at 90% relative humidity, the cell failed to operate after one week in each case, whereas at 58% relative humidity, the cell continued to function properly for the full test.

Thus there has been described an improved housing for an electrical device which may utilize and extend the useful life of a standard high current zinc/air cell. The housing itself controls the rate of ingress and egress of water vapor, slowing down changes in relative humidity conditions which shorten cell life. The housing also controls the rate of supply of oxygen to an air reservoir containing the zinc/air cell so as to cause it to more closely match the requirements of the electrical device. In modified form, the housing also provides the aforesaid advantages but is rendered resistant to liquids with a membrane disposed to prevent the entry of water. The membrane assures a flow of air through the restricted flow passage controlling usage of the cell inside the housing, while acting together with the restricted flow passage to reduce the ingress and egress of water vapor.

By slowing the diffusion of water vapor into and out of the air reservoir in which the cell is located, the cell life is substantially increased.

While there has been described what is considered to be the preferred embodiment of the invention and several modifications

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thereof, it is desired to secure in the appended claims all such modifications as fall within the true spirit and scope of the invention.

We claim:

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## CLAIMS

1. A container for slowing the ingress and egress of water vapor to and from a high current capacity metal air cell connected to an electrical device having low average current requirements, said metal air cell and said electrical device both to be disposed within said container, said metal air cell having air entry ports for admitting a flow of oxygen, said container comprising:

a sealed housing defining an air reservoir for containing said metal air cell, said sealed housing having a wall defining a restricted flow passage communicating between said air reservoir and the atmosphere outside the housing and sized to admit a preselected flow rate of air to said air reservoir sufficient only to satisfy said low average current requirements of the electrical device.

2. The container according to Claim 1, wherein the restricted flow passage comprises at least one hole in said wall.

3. The container according to Claim 1, wherein the restricted flow passage is a hole in the housing wall having a diameter between 0.05 and 0.1 mm.

4. The container according to Claim 1, wherein said housing further includes a hydrophobic gas permeable member defining a chamber between the restricted flow passage and the atmosphere outside the housing and adapted to block entry of liquid into said chamber, and further adapted to admit a preselected flow rate of oxygen to said chamber sufficient to satisfy said low average current requirements of the electrical device.

5. The container according to Claim 1, wherein said housing includes a removable cap for access to the metal air cell, said wall being disposed in said cap.

6. The container according to Claim 1, wherein said housing defines first and second compartments for said metal air cell and said electrical device respectively, and includes a removable cap for access to the first compartment, said air reservoir being located in the first compartment.

7. A container for extending the life of a high current capacity metal air cell connected to an electrical device of the type having low average current requirements with intermittent high current requirements, said metal air cell and said electrical device both to be disposed within said container, said metal air cell having air entry ports sized to admit a sufficient flow of oxygen to satisfy the high current requirements, said container comprising:

a sealed housing defining an air reservoir for containing said metal air cell, said sealed housing having a wall defining a restricted flow passage communicating between the air reservoir and the atmosphere outside the housing and sized to admit a preselected flow of air to said air

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reservoir sufficient only to satisfy the low average current requirements of the electrical device, the volume of said air reservoir being preselected to satisfy a preselected average current drain for a preselected time when the restricted flow passage is blocked.

8. The container according to Claim 7, wherein the restricted flow passage comprises at least one hole in said wall.
9. The container according to Claim 7, wherein the restricted flow passage is a hole in the housing wall having a diameter between 0.05 and 0.1 mm.
10. The container according to Claim 7, wherein said housing further includes a hydrophobic gas permeable member defining a chamber between the restricted flow passage and the atmosphere outside the housing and adapted to block entry of liquid into said chamber, and further adapted to admit a preselected flow rate of oxygen to said chamber sufficient to satisfy said low average current requirements of the electrical device.
11. The container according to Claim 7, wherein said housing includes a removable cap for access to the metal air cell, said wall being disposed in said cap.
12. The container according to Claim 6, wherein said housing defines first and second compartments for said metal air cell and said electrical device respectively, and includes a removable cap for access to the first compartment, said air reservoir being located in the first compartment.

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13. A water resistant wristwatch case for use with an electronic watch movement requiring current- drain for timekeeping in the 2 to 250 microampere range and occasional supply of current in the 2 to 12 milliamperere range from at least one zinc/air high current cell, resulting in a low average current drain, the watch movement and the zinc/air cell both to be disposed in said watch case, the watch case comprising:

a sealed housing defining an air reservoir for containing the zinc/ air cell, said housing having a wall defining an aperture, and a hydrophobic gas permeable membrane covering said aperture, said wall defining a restricted flow passage leading from said aperture to said air reservoir, said restricted flow passage being adapted to admit a preselected flow rate of oxygen to said air reservoir only sufficient to support continuous operation of said cell at said low average current drain, said membrane being adapted to admit a preselected flow rate of oxygen to said restricted flow passage sufficient to support operation of said cell at said low average current drain.

14. The container according to Claim 13, wherein the restricted flow passage is a hole in the wall having a diameter on the order of .08 mm.

15. The container according to Claim 13, wherein the aperture has a diameter on the order of 1.75 mm and the membrane is of GORE-TEX®.

16. The container according to Claim 13, wherein the restricted flow passage and the membrane are selected to support low average current drain on the order of 2 milliamperes.

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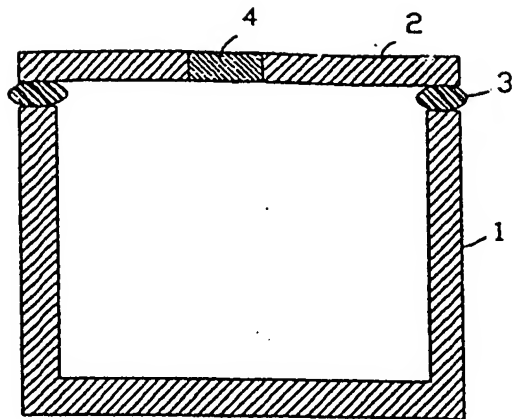


FIG. 1 (Prior Art)

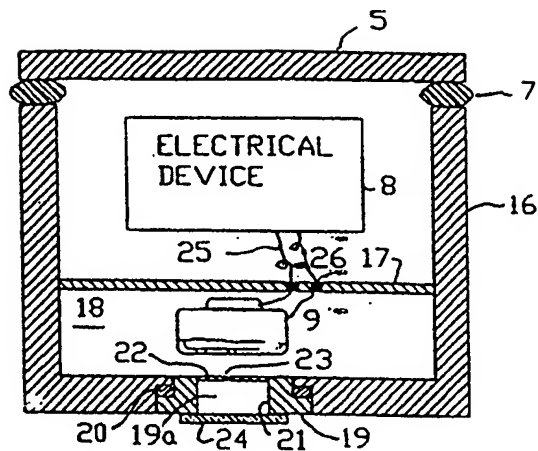


FIG. 4

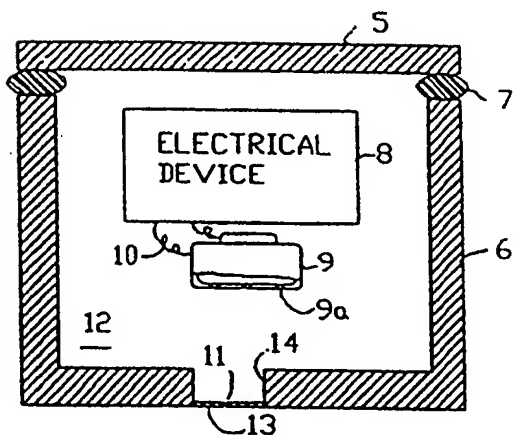


FIG. 2

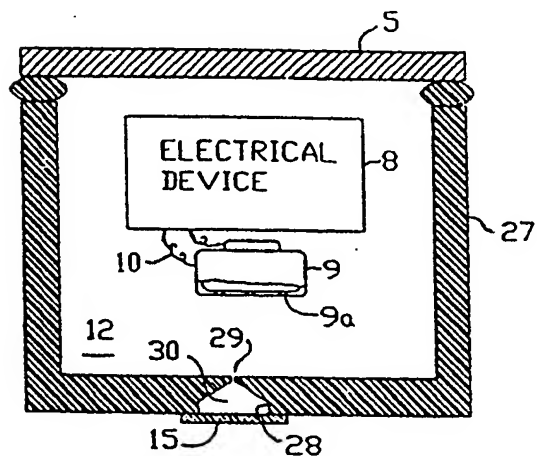


FIG. 5

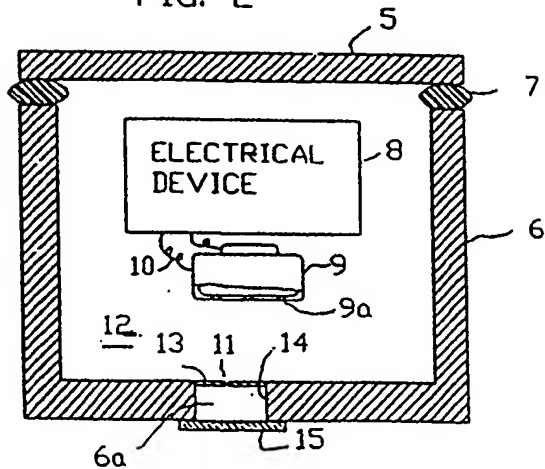


FIG. 3

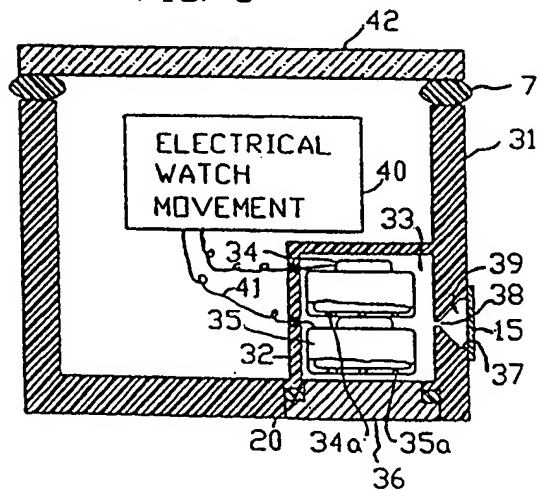


FIG. 6

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/07328

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : HO1M 1/16, G04 37/00  
US CL : 368/204,276

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 368/204,276,10,203,327

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,292,681 A (KLOSS ET AL) 29 September 1981 (29-09-81), Figure 1.	1-16
Y	US 4,262,062 A (ZATSKY) 14 April 1981 (14-04-81), Figure 1.	1-16
Y	US 5,307,520 A (OYAMADA ET AL) 26 April 1994 (26-04-94), figure 2, A, 20.	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*B* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*a* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

15 JUNE 1998

Date of mailing of the international search report

14 SEP 1998

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